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Trauma in pregnancy

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The management of the traumatized pregnant patient is, unfortunately, common in the practice of emergency medicine. Most injuries are caused by motor vehicle crashes, but domestic violence, penetrating trauma, and head injuries are also frequently seen. Trauma complicates at least 6% to 7% of all pregnancies, and it is the most common cause of nonobstetric morbidity and mortality in pregnancy [1–4]. Although managing the traumatized pregnant patient can be somewhat intimidating, successful outcomes for both the mother and fetus can be achieved with a clear understanding of the anatomic and physiologic changes of pregnancy and pregnancy-specific injuries that commonly occur. The emergency physician should be familiar with the standard evaluation of blunt and penetrating trauma and the diagnostic studies commonly employed in evaluating these patients. The changes presented by pregnancy can challenge even the most experienced emergency physician.

Anatomic and physiologic changes in pregnancy

Understanding the normal anatomic and physiologic changes in pregnancy is critical to trauma management. The heart rate increases 10 to 15 beats per minute above baseline, and the cardiac output increases by 30% to 50% before it plateaus at the end of the second trimester. Progesterone-related smooth muscle relaxation leads to a significant decrease in the total peripheral resistance, and thus the central venous pressure slowly drops from 9 mm Hg to a third trimester value of about 4 mm Hg. Blood pressure gradually decreases in the first trimester, reaching

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its nadir toward the end of the second trimester, with the systolic and diastolic pressures decreasing by 5 to 15 mm Hg. During the third trimester, the blood pressure gradually climbs, returning to nearly prepregnancy readings at term. During pregnancy, blood volume increases by 50%, while red blood cell volume increases only about 30%. This dilution results in the so-called ''physiologic anemia'' of pregnancy and an average hematocrit of 32% to 34%.

These hyperdynamic and hypervolemic adaptations help the pregnant patient tolerate the increase in the metabolic demands of the fetus and the expected hemorrhage of childbirth. The average estimated blood losses for a vaginal delivery and cesarean section are approximately 500 mL and 1000 mL, respectively. In term patients, this amount of hemorrhage typically causes no change in hemodynamic parameters. With significant blood loss, the maternal systemic blood pressure is preserved at the expense of the uteroplacental and splanchnic circulation. Thus, the pregnant trauma patient's vital signs may lead to a false sense of security, because changes in pulse and blood pressure may not occur until hemorrhage of 1500 to 2000 mL. Positioning plays a significant role as well. The uterus grows from 70 g to 1000 g, and the entire uterofetoplacental unit averages 4500 g at term. In the supine position, the uterofetoplacental unit may compress the inferior vena cava and decrease preload to the point that it significantly diminishes cardiac output. This diminished cardiac output may cause significant hypotension.

Pulmonary and acid-base changes are adaptations to the increasing metabolic demands and oxygen delivery to the fetus. Overall, oxygen consumption increases by 15% to 20% during pregnancy. Progesterone stimulates the medullary respiratory center, initially leading to hyperventilation and a respiratory alkalosis. After metabolic compensation caused by renal bicarbonate excretion, there still remains a slight alkalemia. The carbon dioxide partial pressure (pCO_2) of the pregnant patient usually ranges from 27 to 32. The tidal volume and minute ventilation increase about 40% as the respiratory rate returns to baseline. The gradual 4-cm elevation of the diaphragm and increasing thoracic anteroposterior diameter contribute to a 20% to 25% decrease in functional residual capacity. This combination of changes, in addition to increasing levels of 2,3-diphosphoglycerate, facilitates oxygen release to fetus. These changes, however, leave the pregnant patient with diminished oxygen reserve and buffering capacity. Hypoxemia occurs earlier than in nonpregnant patients, and, when it does occur, the patient is ill prepared to compensate for the ensuing acidosis. Fetal arterial oxygen pressure (PaO_2) decreases minimally provided that maternal PaO_2 remains above 60 mm Hg; however, it will drop precipitously below this level. When fetal oxygen saturation drops by 50%, the so-called fetal ''diving reflex'' shunts fetal blood flow to the heart, brain, and adrenal glands, leaving other organ systems at risk for insult [39].

In addition to the cardiovascular and pulmonary systems, other organ systems also undergo significant changes. The potential for aspiration is

markedly increased because of decreased gastric tone, delayed gastric emptying, cephalad displacement of intra-abdominal organs, and an increase in baseline gastric acid production. The pregnant trauma patient is more susceptible to genitourinary injury. The uterus displaces the bladder anteriorly and superiorly, so that the bladder becomes an intra-abdominal organ. In addition, the renal pelvises and ureters become dilated. Abdominal tenderness, rebound, and guarding may be absent in the trauma patient with significant injury. Gradual growth and stretching of the peritoneal cavity seems to desensitize the pregnant patient to peritoneal irritation. Most coagulation factor levels rise throughout pregnancy, although laboratory values remain unchanged, except for fibrinogen levels which nearly double in value.

Prehospital care

Although the guidelines for prehospital trauma care generally apply, there are specific issues related to the traumatized pregnant patient. Upon initial assessment, emergency medical service personnel should follow standard guidelines for trauma care. Extrication should be performed in normal fashion, and spinal immobilization should be employed in most patients, especially those with blunt trauma. Placing the patient on a backboard with a 15° angle to the left is a pregnancy-specific intervention that should be employed in all patients beyond 20 weeks' gestation. This precaution relieves, at least partially, the compressive effect of the gravid uterus on the vena cava, which can reduce maternal cardiac output up to 30%. The use of towels or blankets placed under the backboard is quick, easy, and effective. Two large-bore intravenous catheters should be placed, and the patient should be given supplemental oxygen.

Gestational age can be approximated by the size of the gravid uterus or by the history obtained from the patient. Fetal viability is likely if the uterine fundal height is between the umbilicus and the xiphoid. Obtaining this information in the field can be extremely helpful, allowing obstetric consultation before the patient arrives at the trauma center. Most pregnant patients should be transported to a recognized trauma center. In some emergency medical service systems, pregnancy is an indication for prehospital trauma triage designation. Although most patients are unlikely to need the resources of the trauma center, prehospital findings of tachycardia (heart rate >110 beats/minute), chest pain, loss of consciousness, and third trimester gestation are independently correlated with the need for a trauma center [5].

General management

The pregnant trauma patient is best cared for using a team approach. The emergency physician should involve the trauma surgeon and obstetrician

early in the care of these patients. The perinatologist may also be an integral member of the team. Because the most common cause of fetal death is maternal death, efforts to assess fetal well-being are secondary to resuscitation of the mother. The health of the fetus, however, may be the most accurate indicator of maternal health. In general, the maternal response to stress is one of self-preservation at the expense of the fetus. Fetal heart tones can be used as part of the vital signs, and a fetal assessment should be performed early as a part of the maternal secondary survey. The authors emphasize that cardiotocographic monitoring (CTM) be initiated in the emergency department as soon as possible.

The primary survey varies little from that of any other trauma patient. When assessing the airway, recall the increased risk of aspiration and consider early endotracheal intubation. This precaution also benefits the fetus, because hypoxia is a significant factor in fetal distress. As always, assume that the patient has a full stomach and may have a cervical spine injury. When assessing breathing, auscultate for breath sounds and obtain pulse oximetry. Although the pregnant patient may be tachypneic in the first and early second trimester, seek out other causes of respiratory compromise in patients closer to term. A chest tube thoracostomy needs to be placed 1 or 2 intercostal spaces higher than usual to avoid diaphragmatic injury. Adequate oxygenation and pulse oximetry monitoring need to be emphasized, because oxygen reserve is significantly diminished. Consider using the lower end dose of succinylcholine, because pseudocholinesterase levels fall in pregnancy [6]. Both nondepolarizing and depolarizing paralytics cross the placenta, and therefore a flaccid, apneic infant may result. The teratogenic effects of most medications used in rapid-sequence intubation are unknown. The risks associated with using paralytics and induction agents are outweighed by the benefits of early intubation.

Assessment of circulation and interpretation of vital signs should also be done in the context of pregnancy-related changes. Patients at greater than 20 weeks' gestation should be placed in the left-lateral decubitus position. Alternatively, one person may be designated to displace the uterus manually off the inferior vena cava and to the left. The evaluation of perfusion includes central and peripheral pulse quality, skin color and temperature, capillary refill, and patient agitation or anxiety. Once again, in patients approaching term, pulse may be 10 to 15 beats per minute above baseline, but blood pressure returns to prepregnancy levels. Doppler fetal heart tones should be obtained as an adjunct to the vital signs. Hypovolemic shock may occur with minimal change in pulse or blood pressure, and fetal distress may be the first sign of maternal hemodynamic compromise. Early crystalloid fluid replacement using at least two large-bore peripheral intravenous catheters is essential. Aggressive transfusion of blood products may provide volume and improve oxygen carrying capacity. As in the nonpregnant population, head injury is a major cause of maternal morbidity and mortality in trauma. In evaluating the disability of a pregnant trauma

patient, seizures should raise the additional concern for eclampsia. Traumatic injuries may mask the expected hypertension and proteinuria, and edema can be overlooked in the face of distracting injuries. As always, exposure, evaluation of the back, and environmental concerns (hypothermia) should not be overlooked in the primary survey.

In the stable pregnant patient, a rapid but thorough secondary survey must include a thorough fetal assessment, including a pelvic examination. A pregnancy history should be obtained from the patient, if possible. Estimated gestational age and viability can be ascertained quickly. At 24 weeks' gestation the fetus is generally considered to be viable, and the uterine fundus can be palpated at 3 to 4 cm (2 to 3 fingerbreadths) above the umbilicus. Above the umbilicus, the fundal height in centimeters measured from the pubic symphysis correlates well with gestational age. The uterus should be palpated carefully, because tenderness and contractions may be overlooked. CTM monitoring, often requested from labor and delivery, should be readily available to patients in the emergency department. Early CTM may yield the only evidence of uterine irritability, because uterine contractions may subside with time. A sterile speculum examination is an integral aspect of the pregnant trauma evaluation. The source of vaginal fluid may be difficult to discern, but ferning and blue discoloration of nitrazine paper may aid in distinguishing alkaline amniotic fluid from urine. Vaginal bleeding may herald placental abruption, uterine rupture, pelvic fracture with vaginal injury, or other injuries. The cervix should be visually inspected for evidence of dilation and effacement. A bimanual examination is an integral part of the secondary survey that is sometime overlooked. Emphasis should be placed on the abdominal examination, because signs of significant peritoneal injury may be masked.

Trauma panels or order sets performed in many emergency departments can be excessive, wasting time and money, but the pregnant patient may warrant more laboratory testing than other trauma patients. These laboratory tests should include hemoglobin, hematocrit, typing and cross-matching, and a gross inspection of the urine. A serum bicarbonate level, blood gas analysis, or lactate level may be considered, because there is some evidence that maternal acidosis may be linked to fetal outcome [7–9]. Prenatal laboratory tests may be helpful for comparison. Placental abruption may be added to the list of possible causes of disseminated intravascular coagulation (DIC) in trauma. A fibrinogen level that is normal in a nonpregnant patient may be an early indicator of DIC and placental abruption in a pregnant trauma patient. A Kleihauer-Betke (KB) test may be considered in an Rh-negative patient with significant trauma. Routine use of KB is not indicated in the emergency department and may not be indicated at all for most patients [10–12].

Multiple studies, mostly retrospective chart reviews, have attempted to identify variables that may aid in predicting fetal outcome in trauma. Few factors were isolated, particularly those that may be identified in the

emergency department. Hypotension seems intuitive and seems predictive in some studies, but other studies have not validated these data [4,9,13–16]. Evidence of initial maternal acidosis seems to be a useful indicator [7–9,56]. Initial pulse, hemoglobin, oxygen saturation and other physiologic or laboratory values were not useful. Fetomaternal hemorrhage has also not been shown to be predictive of fetal outcome [5,10,11]. The factor most consistently identified, the Injury Severity Score, may be helpful to the trauma surgeon, but unfortunately it is not available to the emergency physician. No single variable is unquestionably predictive for the emergency physician.

In cases of recent maternal death with potential fetal viability, perimortem cesarean section should be performed. When performed early in maternal cardiac arrest, it yields good fetal survival and may improve maternal hemodynamics, as well [12,15,17–19]. This subject is discussed in depth in a separate article.

Diagnostic and radiographic studies

The evaluation of the pregnant trauma patient should focus on the identification of maternal injuries and the evaluation of fetal well-being. In general, diagnostic studies should be obtained in the pregnant trauma patient for the same indications as in nonpregnant patients. Some special management options, however, should be considered in pregnant patients to assure good outcomes. Initial plain radiographs of the cervical spine, chest, and pelvis should be obtained in traumatized pregnant patients as usual. Chest radiographs must be interpreted in the context of pregnancy-related changes. Increased AP diameter, mild cephalization of pulmonary vasculature, cardiomegaly, and a slightly widened mediastinum are seen in normal pregnancy. Similarly, pelvis radiographs reveal widening of the sacroiliac joints and the pubic symphysis.

Radiographic studies should not be withheld because of concerns about radiation exposure. The risk of radiation to the fetus depends on multiple variables, including gestational age, shielding of the uterus, techniques used, and specific studies obtained. As a general rule, it is assumed that the earlier in gestation and the higher the dose, the greater is the risk from radiation. The most sensitive time for the fetus to be exposed to significant radiation is from 2 to 7 weeks, during organogenesis. Unfortunately, at this period of highest risk, the pregnancy may be unsuspected by the patient. A radiation dose of less than 1 cGy (rad) is believed to carry very little risk. Exposures of 15 cGy, however, carry a 6% chance of mental retardation, a 3% chance of childhood cancer, and a 15% chance of microcephaly [20]. Typically, a plain pelvis radiograph will expose a fetus to approximately 1 cGy. Plain radiographs of the cervical spine and the chest hold very little exposure risk, especially if the uterus is shielded. After 20 weeks' gestation, radiation is unlikely to cause any fetal anomalies, particularly if cumulative exposure is less than 10 cGy [21].

Computed tomography (CT) is widely used in the evaluation of traumatic injuries, particularly in head, chest, and abdominal/pelvic trauma. The specific radiation doses used vary depending on the technique of the study and the type of machine used. Newer CT scanners tend to use less radiation than their predecessors, but even the newer machines expose the fetus to a significant dose. A typical abdominal CT will expose a fetus to 5 to 10 cGy. Head and chest CT scans are generally safer, with minor exposures with uterine shielding. As a general rule, abdominal CT should be avoided in early pregnancy; other diagnostic modalities, such as ultrasound and diagnostic peritoneal lavage, are acceptable alternatives. CT, however, does afford a better visualization of retroperitoneal and intrauterine injuries. Head and chest CT may be used when indicated, because the radiation is much less and because there are few, if any, alternative diagnostic modalities.

Diagnostic peritoneal lavage (DPL) is still commonly used in trauma centers to identify intra-abdominal injury. DPL has proven to be a safe and accurate alternative to diagnostic imaging for identification of peritoneal injury using the usual criteria [8,15,22]. If used in pregnancy, a supraumbilical approach is indicated when the gravid uterus is palpable above the pubis. Although the percutaneous, wire-guided Seldinger technique is commonly used in nonpregnant patients, the open-technique or the minilaparotomy technique should be employed in all pregnant patients. This technique carries a lower risk of complications, particularly inadvertent uterine and fetal injury. Proponents of DPL emphasize the increased sensitivity for identifying hollow-viscous injuries and early identification of the need for immediate laparotomy in the case of massive hemoperitoneum. With the use of ultrasonography and with the judicious use of observation with serial abdominal examinations in trauma patients, DPL may become even less common. The focused abdominal sonogram of trauma (FAST) has been shown to be sensitive in identifying peritoneal fluid [23–26]. Clearly, the use of an invasive test with significant complications such as bowel perforation or vascular injury should be abandoned, if a safer and equally sensitive alternative such as FAST examination becomes commonplace. The pregnant trauma patient, however, may be one of the few remaining indications for DPL. The first trimester pregnant patient with an equivocal FAST examination may be a candidate for DPL, avoiding exposure to large amounts of radiation. Later in pregnancy, DPL may help differentiate between massive peritoneal bleeding from an ureteroplacental source, once again in a patient with an equivocal FAST examination.

In a stable patient, a trauma and obstetric ultrasound evaluation should be performed in the emergency department as soon as possible. The use of the FAST examination has become routine in recent years at many trauma centers. It is widely used by trauma surgeons and emergency physicians, who, after minimal training, are able to reproduce the high sensitivity and accuracy for identification of free intraperitoneal fluid [24,25]. A study of the

rapid ultrasound in the pregnant trauma patient yielded comparable sensitivity and specificity [23]. Its use in the pregnant trauma patient has several potential advantages. First, there is no risk of radiation exposure for the fetus. A fetal assessment can be obtained quickly, using some or all of the components of the biophysical profile. The fetal heart rate and reactivity (non-stress test) can be accurately determined and differentiated from maternal tachycardia, and an accurate gestational age can be determined. Amniotic fluid volume can be assessed if there is concern for rupture of membranes. The remaining three components are gross fetal movement, tone, and respiratory activity. Finally, when ultrasound is used, placental abruption may potentially be identified. Although abruption cannot be ruled out with ultrasonography alone, visualization of subchorionic hemorrhage or a retroplacental clot may allow early diagnosis.

Blunt trauma

Most cases of blunt trauma are related to motor vehicle accidents, followed by falls and direct assaults. Motor vehicle accidents account for nearly 60% of blunt traumas (Table 1) [4,5,7,8,10–12,15,16,27–30]. Only falls do not seem to be evenly distributed throughout pregnancy, with more than 80% occurring after 32 weeks' gestation in one series [31]. In blunt trauma patients, the most common cause of fetal death is maternal death [4,32]. Maternal mortality is uncommon and often, as in nonpregnant patients, is a result of significant head trauma. Pregnant women are less than other motorists likely to wear seat belts, usually because of concerns for fetal injury. Crosby and Costilioe [32] found no evidence that seat belts increase or decrease overall mortality in pregnant patients. They did find an increased mortality in mothers and fetuses ejected from the vehicle, and their data suggest that seat belts worn to prevent ejection may significantly impact mortality [32]. The American College of Obstetricians and Gynecologists fully endorses the use of a three-point safety restraint, with the lap belt over the hips, not the uterine dome [33].

If the mother survives, placental abruption is the most common cause of fetal mortality. Shearing forces lead to a separation of the rigid placenta from the elastic uterus. Relatively minor trauma may result in placental separation and fetal demise [4,5,11,29,34–36]. The incidence of placental

Table 1
Incidence of various types of blunt trauma in pregnancy

Type of blunt trauma	Total number (%)
Motor vehicle accidents/pedestrians	1098 (59.6)
Falls	411 (22.3)
Direct assaults	308 (16.7)
Other	24 (0.1)

Data from Refs. [4,5,7,8,10–12,15,16,27–30].

abruptions may be as high as 2% to 4% of patients with minor trauma; others have shown the incidence to be 30% or higher in mothers who survive major trauma [4,5,29]. Clinical signs and symptoms of abruption, such as vaginal bleeding, abdominal pain and tenderness, and uterine tenderness, may be helpful if present, but they are often absent and cannot be relied upon [11,12,29,35]. Pepperell [37] found that only 6 of 16 trauma patients with placental abruptions had vaginal bleeding. Back pain may be the only sign of a posterior placental abruption. Ultrasound may be used as a screening test, but its sensitivity is well under 50% [11,29].

Although rare, uterine rupture is one of the most serious complications of blunt trauma in pregnancy. It occurs most frequently in patients who have had a previous cesarean section. Signs and symptoms of rupture may be similar to those of placental abruption, and the patient may have normal vital signs or be in frank shock. Findings on physical examination may include uterine tenderness with irregular contours and palpable fetal parts. As in abruption, vaginal bleeding may be conspicuously absent. Rupture of the unscarred uterus tends to occur posteriorly and is commonly associated with bladder injury, occasionally presenting with blood or meconium in urine [38]. Uterine rupture is devastating to the fetus, with fetal mortality approaching 100%. Maternal mortality of 10% is usually a result of associated injuries [39].

CTM has shown excellent sensitivity in detecting placental abruption. Connolly et al [10] demonstrated a negative predictive value of 100% for adverse outcomes when a lack of clinical early warning symptoms was combined with reassuring monitoring. Unfortunately, the length of monitoring was at the discretion of the attending physician. Pearlman et al [29] prospectively studied a cohort of pregnant trauma patients and monitored them for at least 4 hours. Thirty percent of patients, those with no clinical evidence of abruption and less than one contraction every 15 minutes, were safely discharged home without any pregnancy-related adverse outcomes. The remaining patients were monitored for at least 24 hours. In 100% of patients found subsequently to have placental abruption, eight or more contractions per hour were present in the first 4 hours. Cases of delayed placental abruption are reported in the literature, and these rare presentations have led some authors to recommended prolonged CTM, sometimes up to 48 hours [40,41]. Towery et al [12] suggest that these cases are delays in diagnosis, not in presentation, and the authors agree. The cases with delayed abruption either lacked initial CTM or would have warranted further monitoring based on uterine irritability.

CTM for a minimum of 4 hours is recommended for all patients of 20 weeks' gestation with any multisystem trauma or even minor abdominal trauma. Monitoring should be initiated as early as possible in the emergency department. If gestational age is unknown, monitoring should be performed until it is determined. Many sources recommend CTM beyond 20 weeks' gestation. Patients at less than 24 weeks' gestation need not be monitored by

obstetricians, however, because delivery by cesarean section for fetal distress is not an option. Emergency physicians should be able to recognize obvious signs of fetal distress. Persistent fetal tachycardia and bradycardia are rarely overlooked, whereas a loss of beat-to-beat variability and the presence of late decelerations are not as easily recognized. Intrapartum fetal pulse oximetry is a technology on the horizon that may help differentiate fetal hypoxia and distress from other nonspecific causes of fetal heart rate changes [42,43].

Penetrating trauma

Several key factors should be considered in the management of penetrating abdominal trauma in the pregnant patient. Penetrating trauma in pregnancy is usually the result of gunshot or knife wounds. Gunshot wounds, which are more common than knife wounds, have a higher mortality for both mother and fetus. As pregnancy advances into the second trimester, the gravid uterus moves out of the relatively protected position in the bony pelvis into the abdominal cavity, and a pregnancy-specific pattern of injury develops. Superiorly displaced visceral organs are less likely to be injured overall, but they are at greater risk when penetrating trauma involves the upper abdomen. The uterus and fetus are at significantly increased risk for direct injury as they grow cephalad.

Nonpregnant patients with abdominal gunshot wounds have an incidence of visceral injury of up to 82% and a corresponding mortality of 12.5% [44]. As a result, the universal recommendation in nonpregnant patients is immediate surgical exploration of these injuries. Maternal visceral injuries are less common during pregnancy, complicating only 19% of cases and carrying a maternal mortality of 3.9% [44]. The disparity probably results from the protective effect of the large, muscular uterus on visceral organs. Gunshot wounds cause transient shock waves and cavitations as they impart their kinetic energy to the high-density tissues of the body, thus causing more severe injury patterns than low-velocity knife wounds. The fetus is at high risk, and fetal injuries complicate 66% of gunshot injuries to the uterus [45]. Fetal mortality ranges from 40% to 70% in cases of penetrating trauma and generally results from either premature delivery or direct fetal injury by the missile [45]. Stab wounds to the abdomen are less common than gunshot wounds in the pregnant patient, and they have a lower mortality for both mother and fetus. Stab wound location is even more crucial in the management of the pregnant patient.

The management of penetrating abdominal injuries is a controversial issue at this time. Management options include immediate surgical exploration, DPL, laparoscopy, contrast-enhanced CT scanning, local wound exploration, and observation. Because the uterus seems to provide some protection from missile injury, a more individualized approach may be appropriate in the gravid victim. If the entrance wound of the bullet is below

the uterine fundus, and the bullet remains in the body of the uterus, the incidence of visceral injury is less than 20% [46]. Because penetrating trauma to the upper abdomen is worrisome for maternal bowel injury, many authorities strongly believe that upper abdominal injuries should be operatively managed [47]. Because trauma over the uterus has a higher risk of fetal injury, an individualized approach has been advocated and may be better suited for lower abdominal injuries [47,48]. The evaluation of penetrating trauma in the pregnant patient needs to be a coordinated, multidisciplinary effort. As in blunt trauma, the biophysical status of the fetus should be ultrasonographically evaluated early in the resuscitation once maternal injuries have been stabilized. Amniocentesis may provide additional information on the viability and possible injury of the fetus. Amniocentesis, however, does carry a significant risk to fetal well-being. The decision to use operative or nonoperative management should be made by the consulting trauma surgeon and obstetrician.

Domestic violence

For emergency physicians, diagnosing domestic abuse may be more crucial than diagnosing a placental abruption. The pregnant patient seems to be at increased risk for domestic violence. This apparent increased risk may be a result of increased incidence, or it may be a result of greater health care use and better detection. Common sites of physical abuse in pregnancy include the face, head, breasts, and abdomen. Domestic abuse may be a risk factor for low birth weight and delay in prenatal care [2,49]. A review of 13 studies found the prevalence of domestic violence to range from 0.9% to 20.1%. The most effective strategies for identifying domestic violence tended to incorporate multiple in-person interviews by highly trained individuals asking specific questions [50]. Using a simple three-question screening tool, McFarlane et al [49] found a 17% prevalence of physical or sexual abuse during pregnancy, a more than twofold increase from previous studies. Sixty percent of abused pregnant women reported two or more occurrences [49]. A heightened index of suspicion and a concise screening tool may afford the emergency physician the unique opportunity to identify, intervene, and prevent reoccurrence of domestic violence. If domestic violence is suspected, consultation with social services should not be delayed.

Burns

Severe burns are uncommon in pregnancy, although the actual incidence of burn injuries in pregnancy is difficult to determine. For the most part, pregnancy does not affect the management of burns. Maternal outcome in cases of significant burns is determined by burn severity and complications, independent of the gravid state [51]. Fetal outcomes are directly related to maternal burn severity and the development of maternal complications.

Aggressive management of these complications and fluid requirements are the best possible treatment for the fetus.

Burn severity depends on both the depth and the size of the burn. Burns are classified as partial thickness (both superficial and deep) and full thickness. Total body surface area (TBSA) can be quickly estimated with the rule of nines, with proportional increasing TBSA for the abdomen as pregnancy progresses. The TBSA of the maternal burn is directly correlated with fetal outcome. Intravascular depletion and third-spacing of fluids may result in uteroplacental hypoperfusion, fetal hypoxia, and distress. Premature labor and death may be the final outcome.

The initial stabilization of the patient should focus on oxygenation, assessment of burn severity, and identification of other traumatic injuries. Early and aggressive intravenous fluid administration is the most important measure, because fluid loss and uteroplacental hypoperfusion are most likely in the first 12 hours after a major burn [44]. The patient should receive appropriate postburn fluid therapy, which can be determined initially by using any of a number of burn resuscitation formulas. The Parkland formula, 4 mL/kg/% TBSA burned, estimates additional fluid requirements for the first 24 hours, with half of the fluid infused over the first 8 hours. A urinary catheter should be placed to ensure urine output of at least 0.5 mL/kg/hour early in the course of therapy. Without a high index of suspicion, carbon monoxide poisoning may be easily missed. Carbon monoxide crosses the placenta freely, and fetal hemoglobin has a higher affinity for icarmon monoxide than does maternal hemoglobin. Carboxyhemoglobin levels do not correlate well with clinical conditions, and the clinical condition of the fetus can be difficult to assess [52]. Because effects on the fetus are devastating, hyperbaric oxygen therapy should be considered early in pregnant patients despite the carboxyhemoglobin level.

After a severe burn, fetal survival is directly related to maternal complications, such as hypoxia, hypotension, and sepsis. Meticulous care must be taken to avoid these complications. In severe burns there is a dramatic increase in fetal mortality, approaching 100% in burns greater than 50% TBSA [53,54]. Some authorities have suggested elective delivery of the second or third trimester fetus if the mother has sustained a burn greater than 50% TBSA [55]. In one series, the fetal survival was 78% if TBSA was less than 30%, but survival fell dramatically to only 6% when TBSA rose above 30% [55]. When fetal death occurs, it is usually within a week of the initial injury. If premature labor is present, tocolytic therapy should be undertaken in consultation with the obstetrician, because tocolytics can cause delirious effects upon the fluid distribution [48]. Initial wound care should be undertaken as in nonpregnant patients, with the application of sterile dressings and topical antibiotics. Early and careful débridement of burn tissue should be undertaken at the discretion of the burn specialists to avoid septic complications. Additionally, some authors recommend that all significant burn patients receive broad-spectrum antibiotic therapy to

prevent sepsis, although this issue is still controversial [46]. Tetanus toxoid and immunoglobulin can be administered safely in pregnancy when indicated. All patients with a major burn (greater than 20% TBSA) should be managed at a burn center, in concert with burn and obstetric consultants.

Summary

The anatomic and physiologic changes make treatment of the pregnant trauma patient complex. The fetus is the challenge, because, in pregnancy, trauma has little effect on maternal morbidity and mortality. Aggressive resuscitation of the mother, in general, is the best management for the fetus, because fetal outcome is directly related to maternal outcome. Recent literature has attempted, with little success, to identify factors that may predict poor fetal outcomes. Cardiotocographic monitoring should be initiated as soon as possible in the emergency department to evaluate fetal well-being.

Other key points include

- Maternal blood pressure and respiratory rate return to baseline as pregnancy approaches term.
- Initial fetal health may be the best indicator of maternal health.
- Inferior vena cava compression in the supine patient may cause significant hypotension.
- Maternal acidosis may be predictive of fetal outcome.
- Kleihauer-Betke testing is not necessary in the emergency department.
- Early ultrasonographic evaluation can identify free intraperitoneal fluid and assess fetal health.
- Necessary radiographs should not be withheld at any period of gestation.
- Radiation beyond 20 weeks' gestation is safe.
- Patients with viable gestations require at least 4 hours of CTM monitoring after even minor trauma.

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